

This paper describes an information content analysis of gas and aerosol retrieval from SWIR and TIR bands. SWIR observations are more sensitive to CO<sub>2</sub> and CH<sub>4</sub> near the surface, but less sensitive to the vertical profiles than TIR observations. A synergy use of these bands is expected to complement one another. Also, optical path modification due to aerosol scattering is one of the major error sources for total-column retrieval from SWIR observations. Therefore, I think the topic of this paper is relevant for AMT. However, there are several concerns; the configurations of analyses are not clear due to the insufficient description; authors made a comments about a satellite mission specification, but the number of considered configuration looks insufficient to make a general conclusion; etc. The major revision is needed before the publication. Followings are the specific comments.

> First, we thank the referee for his very useful comments, which have helped improving the manuscript.

Below are the responses to his comments and suggestions.

1. Introduction

Earlier paper by Christi and Stephens (2004, JGR, D04316) should be cited.

>This reference has been added and discussed.

2. p.8438, l.13-14

Please add " Band 1/2/3/4" in the text.

> We have added this information in the text.

3. p.8443, l.5

where  $S_{a,i}$ => where  $\sigma_{a,i}$ ?

4. p.8443, l.13

where  $S_{m,i}$ => where  $\sigma_{m,i}$ ?

> For the sake of reducing the size of the paper we originally chose to define the measurement ( $S_m$ ) and prior covariance matrix ( $S_a$ ) by the element (i,i) of their diagonal. This element is defined from the standard deviation of the ith measurement ( $s_{m,i}$ ) and ith parameter of the state vector ( $s_{a,i}$ ) respectively. The whole measurement and prior covariance matrix are now explicitly derived in the revised version.

5. SNR of TANSO-FTS(p.8443, l.15)

A simple description of "a signal to noise ratio of about 300" might lead a misunderstanding to readers. According to Kuze et al. (2009), requirement of SNR larger than 300 is defined under the condition of solar zenith angle of 30 degree and surface albedo of 0.3. It is better to add explanation.

Kuze et al. (2012, AMT) said there are two dominant noise sources for TANSO-FTS; (1) the detector and its electronics noise and (2) the shot noise. The former noise looks dominant because darker (brighter) surface gives lower (higher) SNR (e.g., Fig. 6 of Yoshida et al. 2011).

> We agree with the referee that this information was missing and the text has been modified accordingly.

6. Surface reflectance (p.8444, l.11)

a) There is no descriptions about surface reflectance/emissivity in section 5. Are surface emissivities (reflectance) of 1/0.98/0.98/0.95 (0/0.02/0.02/0.05) for Bands 4/3/2/1 used in the analysis of section 5 ? If so, the reflectances for SWIR bands are too low(see comment 5). Only water surface has such a low reflectance at SWIR bands, however, TANSO-FTS observes sun-glint region to avoid low SNR measurements over the dark water surface.

> We have added a table that summarizes all the parameters using for the analyses, in particular the surface reflectance/emissivity for the Bands 4/3/2/1.

b) Many earlier papers discuss about the interaction between aerosol and surface reflectance in the total-column retrieval from SWIR observations (e.g., Butz et al. 2009, Appl. Opt.). Additional analyses with several values of surface reflectance should be made.

> We agree with the referee. Thus, we have completed our study with 3 typical surfaces (ocean, vegetation and desert) corresponding to low, medium and high reflectance surfaces and signal to noise ratios.

7. p.8444, l.12

$(p_e) \Rightarrow (p_e)$  ?

8. p.8444, l.15

$(P_{Cmol}) \Rightarrow (p_{Cmol})$  ?

>Sorry, it's only a typo?

9. p.8445, l.7

"atmospheric column concentrations"  $\Rightarrow$  "profiles"

> This has been corrected.

10.p.8445, l.9, p.8451, l.12-14

Yoshida et al. (2011) used Bands 1 and 2 of TANSO-FTS. Band 3 was only used for cirrus screening.

> These lines were rewritten to avoid any confusion.

## 11. Configuration of the analysis

To avoid the misunderstandings, please clarify following points for each case.

a) Retrieved parameters and non-retrieved parameters. It is not clear that CO<sub>2</sub>, CH<sub>4</sub>, and H<sub>2</sub>O are retrieved simultaneously or independently. Also, typical simultaneously retrieved parameter of surface reflectance and temperature are included in the retrieved parameter or not.

b) Used bands and non-used bands. It is not clear that Band 1 is used in section 5.1 and 5.2 or not.

> As already stated (question 6), for the sake of clarity and convenience, we have added a table similar to Yoshida et al., 2011 and O'Dell et al., 2012. This table summarizes the state vector parameters including a priori values and errors, as well as values and errors of the non-retrieved parameters, and the Bands used.

c) Vertical gridding. Many literatures show US standard profile with 1-km resolution; 21 vertical levels from the surface to 20 km. Which boundaries do you used ? Further, vertical grid of Figs. 2 and 4 looks different with that of Figs. 3 and 5. Please clarify.

> The vertical grids of Figs 2, 3, 4 and 4 are the same and the boundaries are identical to Herbin et al., 2009. However, as suggested by the reviewer, and to facilitate the comparison with previous studies, we have changed the vertical grinding to 21 vertical levels from the surface to 20 km.

d) Solar zenith angle and viewing angle.

>To compare our results with Christi and Stephens (2004, JGR, D04316) the SZA and viewing angle are assumed to be 30° and Nadir respectively.

12.p.8445, l.14

What is "the vertical DOFs" ? Eq. (3) gives a single scalar value regardless the number of retrieved parameters.

> We apologize for this lack of explanation concerning the vertical dofs. As stated by Rodgers (2000) page 54 (iv), the diagonal element of the averaging kernel (A) can be seen as a measure of the number of degree of freedom per level. We have added this explanation in the text and we now show the averaging kernel directly as well as kernel area instead of the diagonal element only.

### 13. Figs. 3 and 5

Although a large uncertainty on the prior state vector is applied, error reduction by SWIR bands seems to be too small. Please add detail explanations about this.

> This effect is due to the assumed surface reflectance which is very small for open ocean in the SWIR. The error reduction should be larger above bright surface as desert and dense vegetation.

According to Eq. (5),  $S_x \approx S_a$  indicates that the spectrum error is larger than Jacobian. It may be helpful to add figures of Jacobian and spectrum error for typical vertical grid.

> As stated in point (12) we now show the averaging kernel and kernel area which should depict very small value at level where  $S_x \approx S_a$ , showing that the retrieval is only sensitive to the a-priori value.

### 14. Fig. 6

Add solar zenith angle, viewing angle, and surface reflectance in the figure caption.

> The caption of Fig 6 has been modified as suggested.

### 15. Fig. 7

According to Figs. 2 and 4, DOFs of H<sub>2</sub>O column by Band 4 only/All Bands analyses are expected to be greater than about 6. Why is the maximum DOFs unity ?

> Because it is not the total degree of freedom but the degree of freedom per level (see point 12). The sum of these degrees of freedom per level is equal to the total degree of freedom.

### 16. Satellite mission specification

If you want to mention about a satellite mission specifications, it is better to show a frequency distribution of aerosol optical thickness. Of course, the retrieval results have large errors when optical thickness is large, but such cases are limited. Do not make a conclusion based on a limited specific case.

> Instead of showing a frequency distribution of aerosol optical depth, we based the aerosol representation on Dubovick et al. (2002) paper and especially on table 1 which summarizes the variability of microphysical properties of different aerosol type from AERONET data. Moreover the goal of this study is to understand the theoretical interest of the spectral synergy to retrieve gases information in presence of different type of aerosol and for a large panel of aerosol loading, instead of building an operational algorithm.

### 17. "column"

In some cases, the word "column" seems to indicate "partial-column", not "total-column". To avoid confusion, please clarify. Be care that DOFs just shows the number of independent parameters obtainable from the measurement and do not show the vertical sensitivity.

> Obviously, the term "column" in our manuscript indicates partial or tropospheric column. Thus, we have taken care to verify in the revised text that this information is explicit. Additional information about the DOFs and vertical sensitivity significance has been added.